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THE EFFECTS OF SMOKING ON TIME ESTIMATION PERFORMANCE

ANNUAL REPORT

Steven T. Breidenbach, James L. Arnold
and Norman W. Heimstra

September 1976

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U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND

Washington, D.C. 20314

Contract No. DADA 17-73-C-3037 (Year 3)

University of South Dakota
Vermillion, South Dakota 57069

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Two investigations were conducted to determine the effects of nicotine on the processing of visually presented information. In both studies, fifteen chronic smokers were tested under smoking and smoking deprived conditions, and ten nonsmokers were tested as a control group. Subjects were deprived of smoking for two hours prior to testing. The test sessions consisted of ten minutes of task performance, during which baseline measures were taken, followed by a ten minute treatment period, during which a cigarette was given to subjects in the smoking treatment, and finally, approximately

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20. Abstract cont.

forty-five minutes of task performance, during which post-treatment measures were taken.

In the first study, subjects were tested on a simple velocity estimation task, viewed in the central visual field. The results indicated that nicotine had an adverse effect on the ability of subjects to perform this task, but only under certain extreme conditions of object speed and viewing time. These results were compared to previous research where detrimental nicotine effects were found over a wide range of speed and concealment values when a similar task was presented peripherally.

In the second study, subjects were required to estimate the velocity of a moving target and fire ahead of it to compensate for the time lag in a projectile trajectory. The results again indicated that smoking and smoking deprived subjects differed only under certain speed and exposure time conditions, but in this case, the smokers actually performed better than the deprived smokers. It was suggested that the higher level of information processing involved in this task was not adversely affected by nicotine.

SUMMARY

Two investigations were conducted to determine the effects of nicotine on the processing of visually presented information. In both studies, fifteen chronic smokers were tested under smoking and smoking deprived conditions, and ten nonsmokers were tested as a control group. Subjects were deprived of smoking for two hours prior to testing. The test sessions consisted of ten minutes of task performance, during which baseline measures were taken, followed by a ten minute treatment period, during which a cigarette was given to subjects in the smoking treatment, and finally, approximately forty-five minutes of task performance, during which post-treatment measures were taken.

In the first study, subjects were tested on a simple velocity estimation task, viewed in the central visual field. The results indicated that nicotine had an adverse effect on the ability of subjects to perform this task, but only under certain extreme conditions of object speed and viewing time. These results were compared to previous research where detrimental nicotine effects were found over a wide range of speed and concealment values when a similar task was presented peripherally.

In the second study, subjects were required to estimate the velocity of a moving target and fire ahead of it to compensate for the time lag in a projectile trajectory. The results again indicated that smoking and smoking deprived subjects differed only under certain speed and exposure time conditions, but in this case, the smokers actually performed better than the deprived smokers. It was suggested that the higher level of information processing involved in this task was not adversely affected by nicotine.

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INTRODUCTION

The possible relationships between smoking and visual functions have been subjected to considerable research. For example, Sheard (1946) investigated the effects of cigarettes on the dark adaptation of rods and cones, Fink (1946) and Castagno (1950) studied the effects of smoking on the increase in the area of angioscotomas while the effects of smoking on the fusion frequency of flicker were examined by Larson, Finnegan and Haag (1959) and Garner, Carl and Grossman (1953, 1954). Numerous other studies have examined the physiological effects of cigarette smoking on visual processes.

Recent investigations by Scoughton and Heimstra (1973, 1975) have focused attention on the effects of cigarette smoking on the processing of information presented in the peripheral field of vision. In viewing objects peripherally for a velocity estimation task, significant differences were found between smoker and smoker deprived subjects. Those in the smoker group had significantly larger error in their time of arrival estimates for the velocity estimation task than did smoker deprived subjects.

Having found significant smoking effects while viewing objects peripherally, a question of practical interest remained as to whether these effects are relevant solely to the peripheral field of vision. If significant cigarette smoking effects were found when perceiving objects in the central visual field then individuals in a variety of activities could be affected. For example, an operator of a motor vehicle must be able to judge the speed of his own vehicle as well as that of other drivers on the road. Similarly, pilots of aircraft are constantly making judgments of closure between their vehicle and approaching aircraft, obstacles during low-altitude flight envelopes, and the ground while landing.

This report presents the findings of a two-part investigation which was conducted to: 1) determine the relationships between cigarette smoking and the ability of subjects to make estimates of closure and escape, and, 2) to determine the relationships between smoking and the ability to anticipate and compensate for inherent time lags in a simulated target acquisition and interception task.

STUDY NUMBER I

INTRODUCTION

Previous research (Scoughton and Heimstra, 1973) has found significant differences existing between smoking and smoking deprived subjects in tasks requiring the estimation of velocity in the peripheral field. The task in the present study required information processing similar to that in previous studies except that stimulus objects (targets) were viewed in the central field of vision rather than in the peripheral field. In this experiment, the targets were generated on a video display screen in order to give the appearance of the target traveling toward or away (approaching or receding) from the operator.

METHODS

Subjects

Subjects consisted of 25 male volunteers from the student population of the University of South Dakota. Fifteen of the subjects were chronic smokers (SM), and the remaining ten were non-smokers (NS). Selection of the subjects was based on a questionnaire concerning smoking habits, health records, and a visual screening test. The visual selection criterion required a subject to possess a binocular acuity of 20/30 or better, corrected or uncorrected. Only individuals that smoked at least 20 cigarettes per day for a period of one year were selected for the smoker group. The criterion for a non-smoker was that the person had abstained from using any form of tobacco for the past year. Volunteers who had high blood pressure or were under medication, such as barbituates or amphetamines, were rejected.

Ages of the subjects ranged from 18 to 25 with a mean age of 20.9 years. Smokers were scheduled for two experimental sessions and were paid a total of fifteen dollars upon completion of the second session. Subjects in the non-smoker group appeared in only one experimental session and were paid seven dollars and fifty cents for their participation.

Prior to any participation in the experiment, subjects were fully informed of the requirements and purposes of the investigation and signed a consent form.

Apparatus and Task

The apparatus employed in this study consisted of a VT8-E video display situated on a table in a room having a low level of illumination.

The display was capable of generating a 200 by 189 dot matrix (11.43 cm. vertical by 17.78 cm. horizontal) directly controlled via a PDP8-E digital computer located in an adjoining room. Both the display and computer are manufactured by Digital Equipment Corporation.

The subject was seated in a chair so that a distance of approximately 75 cm. separated his eyes from the display screen. On the display screen, a small rectangle (1.43 cm. by 2.35 cm.) appeared to be positioned behind a large rectangle (10.57 cm. by 17.40 cm.). Figure 1 is a schematic of the display screen showing the orientation of the two rectangles. In order to create a three dimensional illusion, two lines connected the two rectangles at their bases.

Two seconds after a buzzer sounded as a warning to signal the start of a trial, a small rectangular target "appeared" out of the smaller rectangle. The rectangular target grew in size giving the illusion that it was approaching the operator. While on its path, the moving target disappeared at one of three points: 3/8, 1/2, and 5/8 of the distance between the two stationary rectangles.

The subject then indicated with a hand held switch his estimate of "impact" represented by the time at which he felt the moving target (which had been concealed at one of the three previously mentioned points) would superimpose the large stationary rectangle. Upon completion of an approaching trial, a receding trial occurred in which a large rectangular target "appeared" out of the larger rectangle and moved toward the smaller rectangle. As in an approaching trial, the target in the receding trial disappeared at one of the three specified distances and the subject indicated, by means of the hand switch, his estimate as to when the "receding" rectangle would superimpose the small rectangle.

Another parameter that was investigated was the velocity of the moving target in both the approaching and receding trials. The three velocities of the moving rectangle (selected through pilot work) were: speed one, .86 deg./sec. vertical and 1.43 deg./sec. horizontal; speed two, .65 deg./sec. vertical and 1.07 deg./sec. horizontal; and speed three, .52 deg./sec. vertical and .85 deg./sec. horizontal. These angular velocities correspond to the rate of increase or decrease in the visual angle subtended by the moving rectangular target, in both approaching and receding trials.

Presentation of trials in this investigation were divided into blocks in order to determine the effects of nicotine over time. A total of thirty-six trials with four trials of each speed and concealment combination were randomly presented within each block. There was a 21 second interval between the initiation of trials.

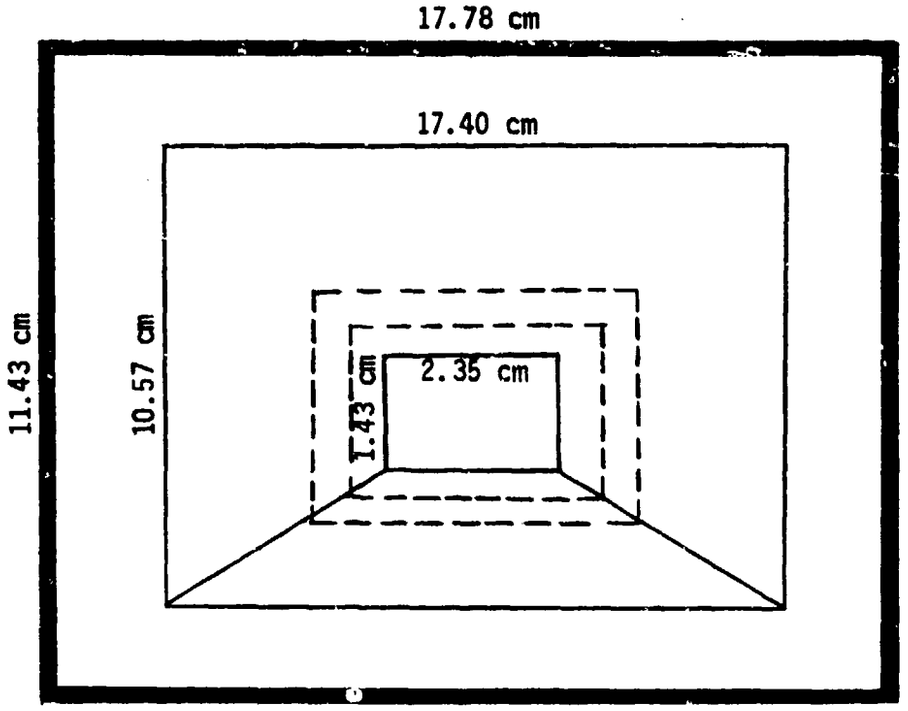

Figure 1

DISPLAY SCREEN SCHEMATIC

Measures

In the scoring of responses, which was done by the computer, the value zero was assigned to those responses in which the moving target had perfectly superimposed the stationary rectangle. Scores with minus signs were assigned when a subject responded too early (the subject pressed the switch before the moving target superimposed the stationary rectangle). Positive scores were assigned to responses which were late.

Three response measures were obtained with each of the measures expressed as deviations from baseline, which was the block of trials prior to receiving the cigarette treatment. These were found by subtracting the measures in the baseline block from the measures in each of the post-treatment blocks.

The three measures obtained in order to estimate a subject's ability to make estimates of closure and escape in the velocity estimation task consisted of the following:

Mean Constant Error. A measure indicating the extent to which a response is, on the average, early or late. It reflects both the magnitude and direction of the error. This measure was derived by calculating the mean of the signed error responses.

Mean Absolute Error. A measure indicating the magnitude of a subject's error. This measure was obtained by calculating the mean of the unsigned error responses.

Root Mean Square Error. A measure of the variability of a subject about his own mean response. The root mean square was acquired by calculating the standard deviation of the signed error responses.

PROCEDURES

The procedures utilized in this experiment were quite similar to those used in previous studies in which a difference in performance between smoking and smoking deprived subjects had been found. Fifteen smokers were tested individually under both a smoking and smoking deprived condition. Each test session was scheduled for the same time of day with approximately 48 hours between the two sessions. Ten non-smoking control subjects appeared for one session under identical conditions as the smoking deprived subjects.

Subjects reported to a lounge two hours prior to actual testing. No food or beverages were allowed during the entire session and all cigarettes were taken away from the subjects serving under the smoking and smoking deprived conditions.

The first fifteen minutes of the session served as a training period for the subjects. After the directions had been fully explained by the experimenter, the subject was seated in front of the display and was allowed to practice on the task which had been explained to him. For training purposes only, feedback concerning amount and direction of error was given at the end of each trial. The same speeds and concealment distances utilized in the actual test session were employed throughout the training. Four trials of each of the nine speed and concealment combinations were presented to a subject. Following the training session, subjects were sent to the lounge for the remainder of the two hour waiting period.

Upon completion of the training session and waiting period, subjects were taken to the experimental room for the testing session which lasted a total of 1 hour and 22 minutes. The first twelve minutes of the testing session served as a baseline period to obtain measures from the subjects prior to administering the smoking treatment. After the baseline period a ten minute break was given to allow subjects in the smoking condition to smoke one cigarette. The unfiltered cigarettes, which were obtained from the Kentucky Tobacco and Health Research Institute, contained 2.5 mg. nicotine and 30 mg. tar. Subjects serving under the smoking deprived and non-smoker conditions were not given a cigarette. After completing the ten minute treatment period, a series of five 12-minute post-treatment blocks were administered.

The subjects who were smokers served under both smoking and smoking deprived conditions. As a means of eliminating practice effects the cigarette treatment was counterbalanced with half of the subjects serving in the smoking treatment the first day and the smoking deprived treatment the second day, while the other half served in the smoking deprived treatment the first day and the smoking treatment the second day. Except for the change in treatment the only difference in the experimental session on the second day was that there was no training at the beginning of the session.

The ten subjects in the non-smoker group appeared in only one experimental session, which was identical to the session for the smoker deprived group.

Data Analysis

The task in this first study was designed to determine the effects of cigarette smoke on the ability of subjects to make estimates of closure and escape of objects viewed in the central field of vision. As a method for determining these effects, each of the three measures obtained (mean absolute error, mean constant error, and root mean square error) was analyzed separately employing an analysis of variance technique. A Biomedical Computer Program (BMDP2V) was used

in the calculation of the analysis of variance to determine the significance of treatments, blocks, speeds, concealment distances and their interactions.

The primary comparison involved in this study was between the smoker and smoker deprived groups. For this comparison, a 2 x 5 x 3 x 3 (smoking treatment, blocks of time, target speeds, and target concealment distances) factorial design with repeated measures across all levels of each factor was utilized in the analysis of variance.

In a repeated measures analysis of variance, the sum of squares comprising the error term is reduced due to the fact that a subject serves as his own control. If one suspects a high degree of between subject variability (as was the case in this experiment), then a repeated measures design will generally yield a more powerful test of effects than a completely randomized design (Winer, 1971).

Other comparisons of interest were between the non-smoker and smoker deprived groups and the non-smoker and smoker groups. In order to test differences between these groups a 2 x 5 x 3 x 3 (smoking treatment, blocks, speeds, and concealments) factorial design with repeated measures over the block, speed, and concealment factors was utilized in the analysis of variance.

RESULTS

All of the statistical tests performed in this experiment employed a probability level of .05 for the criterion on Type I error.

In the comparison of primary interest between smoker and smoker deprived groups for mean absolute error (Table 1), there was a significant smoking treatment x speed x concealment interaction ($p = .027$). There was also a near significant main effect for the smoking treatment. To determine the differences between the two treatment groups, tests of simple effects were performed at each speed and concealment combination. Results of the simple effects tests (Table 2), show that the smoking treatment group differs significantly from the smoker deprived group at the speed one (fastest speed) and concealment one (moving target visible for the shortest time) combination. There was also a notable difference for the speed three (slowest) and concealment two combination. Figure 2 graphically shows the relationships between the two treatment groups for each speed and concealment combination. In both instances where significant differences were found, the smokers had larger errors than the deprived smokers.

An analysis of variance summary table for mean constant error (Table 3) reveals a significant main effect for speed ($p = .027$). There were also near significant effects for concealment, speed x concealment, and smoking treatment x speed x concealment. Since the data used in the analysis were deviation from baseline scores,

Table 1

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	8.51878	4.37947	.055
B	4,56	.28267	.61132	.656
TB	4,56	.37434	.72190	.581
S	2,28	3.06965	.64620	.532
TS	2,28	1.71700	1.17218	.324
BS	8,112	.10931	.44137	.894
TBS	8,112	.17580	.62175	.758
C	2,28	.14771	.09736	.908
TC	2,28	.62333	.55948	.578
BC	8,112	.09388	.42359	.905
TBC	8,112	.36054	1.54174	.151
SC	4,56	2.54498	2.00377	.106
TSC	4,56	4.15415	2.98089	.027
BSC	16,224	.26553	1.27275	.216
TBSC	16,224	.41941	1.86773	.025

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

Table 2

TEST OF SIMPLE EFFECTS
SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	MS	F	p <
T at S1C1	13.392	9.610	.01
T at S1C2	2.155	1.546	
T at S1C3	.081	.058	
T at S2C1	.357	.256	
T at S2C2	.333	.239	
T at S2C3	1.433	1.028	
T at S3C1	5.396	3.872	
T at S3C2	5.928	4.254	.05
T at S3C3	.745	.534	
ERROR	1.394		

df = 1,56
$F_{.05}(1,56) = 4.02$

T = Smoking Treatment
S = Speed of Moving Target
C = Concealment of Target

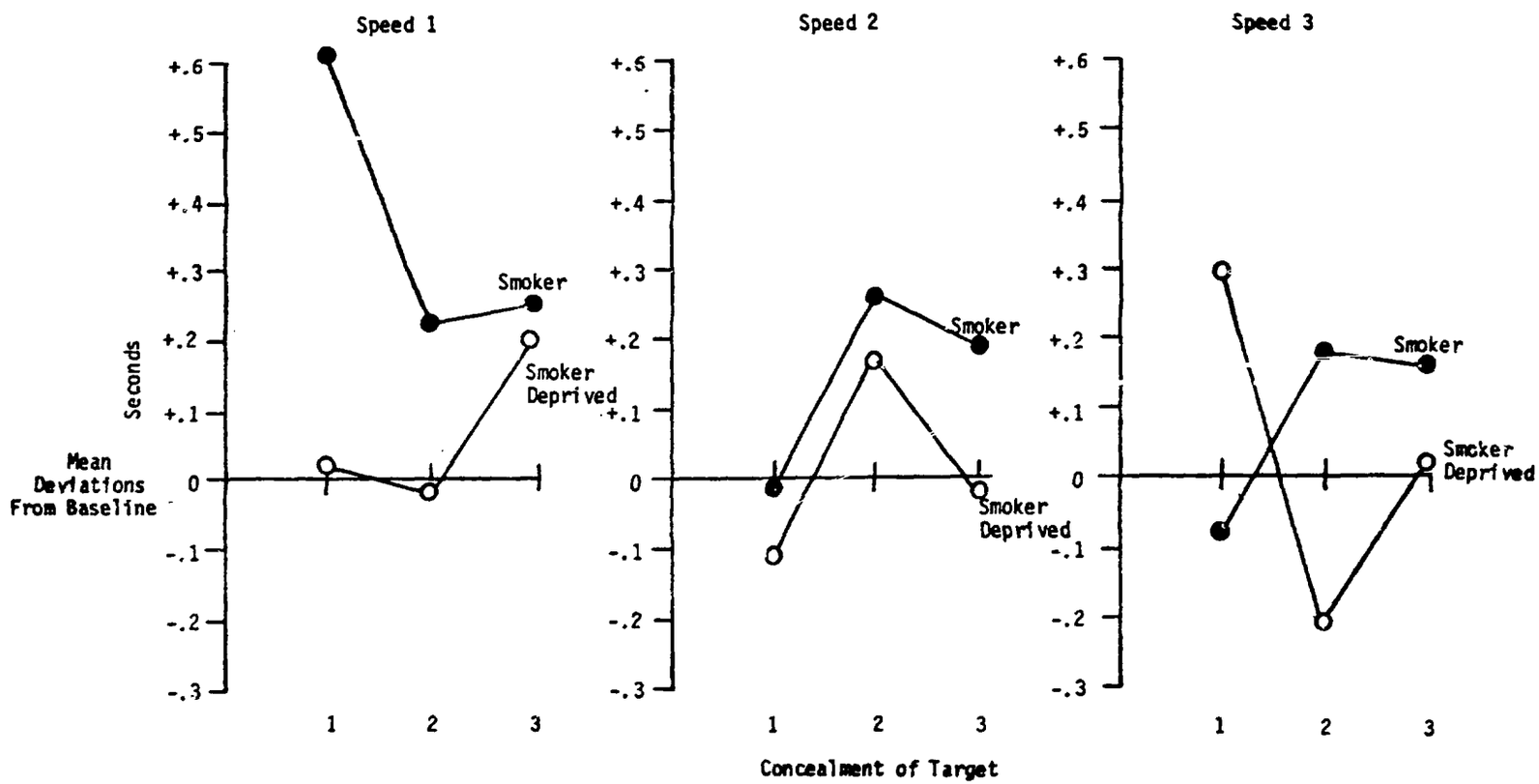

Figure 2

SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Table 3

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	18.58308	1.58722	.228
B	4,56	.70658	.49871	.737
TB	4,56	.18185	.15491	.960
S	2,28	13.56878	4.12936	.027
TS	2,28	.35566	.25687	.775
BS	8,112	.28172	1.22943	.288
TBS	8,112	.29529	1.20284	.304
C	2,28	7.09409	3.01451	.065
TC	2,28	1.45536	.72924	.491
BC	8,112	.35694	1.19286	.310
TBC	8,112	.33063	.84129	.568
SC	4,56	5.79521	2.37452	.063
TSC	4,56	3.24010	2.40114	.061
BSC	16,224	.33178	1.00234	.455
TBSC	16,244	.23498	.64248	.847

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

significant main effects for either the speed or concealment factors are not of practical interest. This is due to the fact that the influence of these factors would not be expected to change from the baseline period to the post-treatment periods. The speed and concealment factors are of interest, however, when considering their interactions with the smoking treatment, since the smoking treatment may be differentially effective at different levels of speed and concealment.

Since the task used in this study was similar in nature to a classical velocity estimation task, means for the three speeds and concealments were plotted in Figure 3. Raw data from the post-treatment trials were used in calculating these means. It can be seen in Figure 3 that the subjects tended to respond late, or overestimate with the fast speed, and underestimate with the slowest speed. It can also be seen that for concealment level three, which had the longest viewing time, there was much less slope in the line, indicating that differences in speed had a smaller effect.

Tests of simple effects were performed on the smoking treatment x speed x concealment interaction. Results of this analysis (Table 4) reveal a significant difference between smoker and smoker deprived subjects for speed one (fastest), concealment one (visible shortest time) and speed three, concealment three combinations. Figure 4 shows the graphic nature of this relationship in both cases, the smoking subjects had the larger error.

Table 5 is the analysis of variance summary table for the smoker vs. smoker deprived comparison using root mean square as the error measure. Block x speed x concealment was a significant interaction ($p = .024$), but this interaction is not of particular interest since it is not related to the smoking treatment. However, there was a near significant smoking treatment by block interaction ($p = .066$). A graph of this interaction in Figure 5 shows that smokers tended to increase in variability (RMS error) across blocks, after an initial reduction in variability immediately following the treatment. Deprived smokers exhibited no change from baseline in the first block, and subsequently decreased in variability, with a return to baseline levels in the final block.

Another comparison of relative importance was between the nonsmoker and smoker deprived subjects. Table 6 contains the analysis of variance summary table for mean absolute error. Smoking treatment x block interaction was the only significant effect ($p = .047$). A graph of this effect in Figure 6 reveals the treatment by block relationship. There appears to be a definite fatigue effect for nonsmokers which is not evident for the smoker deprived subjects.

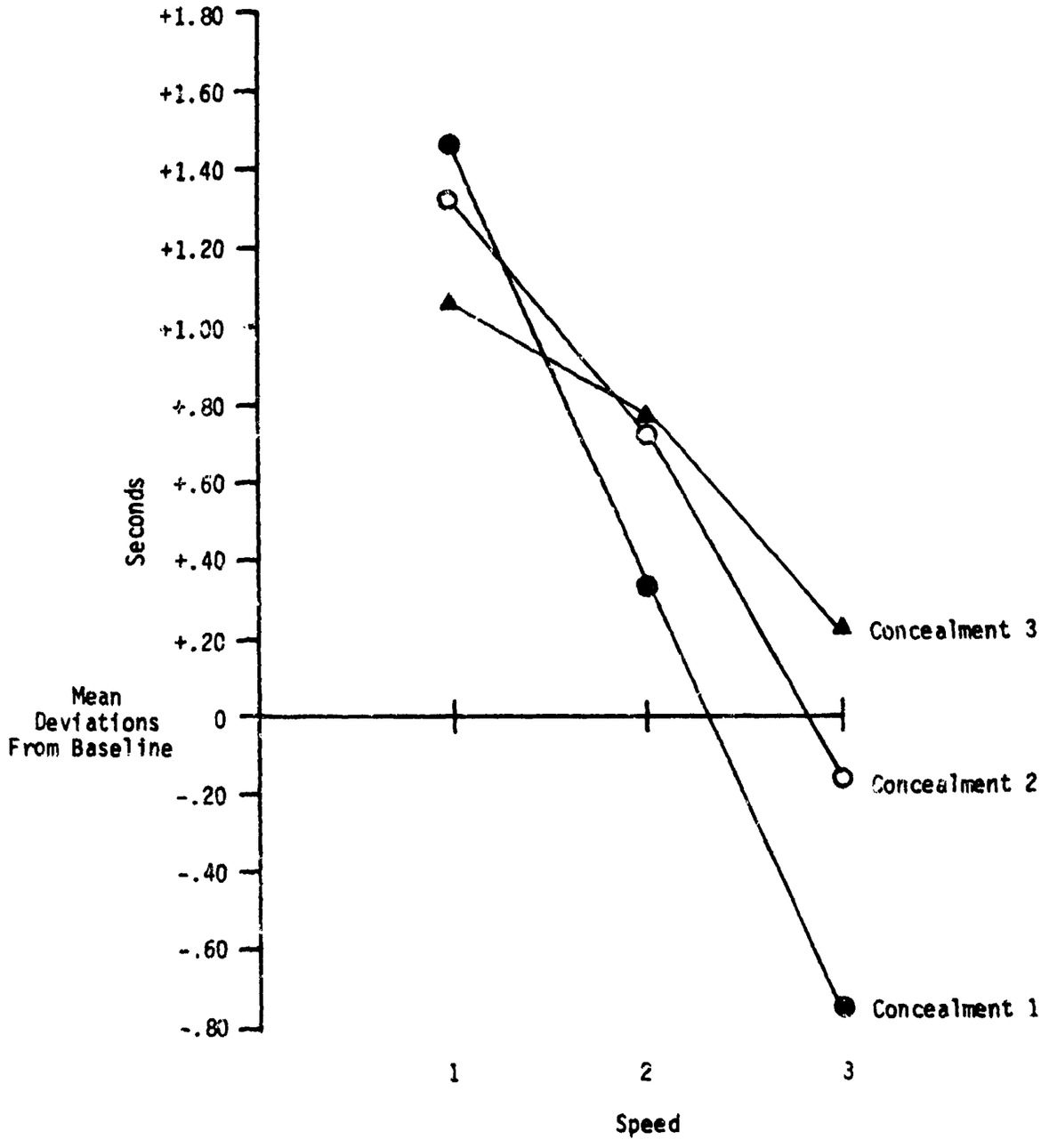

Figure 3

SMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR
POST-TREATMENT SCORES

Table 4

TEST OF SIMPLE EFFECTS
SMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Source	MS	F	p <
T at S1C1	16.71	12.38	.01
T at S1C2	.15	.11	
T at S1C3	.16	.12	
T at S2C1	2.96	2.19	
T at S2C2	3.15	2.33	
T at S2C3	.57	.42	
T at S3C1	.83	.62	
T at S3C2	2.70	2.00	
T at S3C3	7.94	5.88	.05
ERROR	1.349		

df = 1,56
$F_{.05}(1,56) = 4.02$

T = Smoking Treatment
S = Speed of Moving Target
C = Concealment of Target

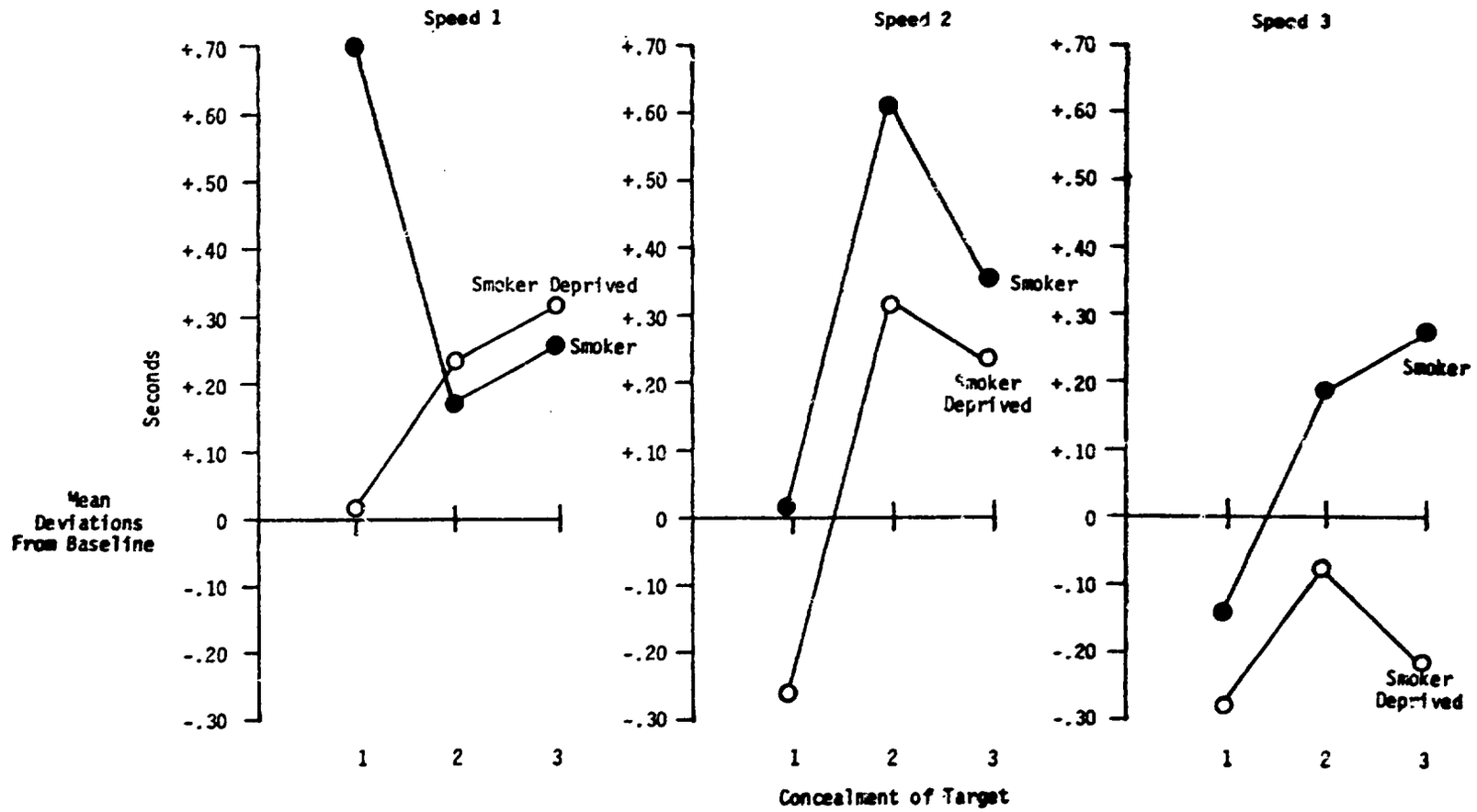

Figure 4

SMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Table 5

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	.03776	.03479	.855
B	4,56	.10516	.26984	.896
TB	4,56	.81018	2.33832	.066
S	2,28	2.60055	1.81580	.181
TS	2,28	1.37164	.93105	.406
BS	8,112	.17341	.57507	.796
TBS	8,112	.09210	.37550	.932
C	2,28	1.55488	1.63875	.212
TC	2,28	.12171	.10415	.901
BC	8,112	.15184	.57855	.794
TBC	8,112	.22288	1.10467	.366
SC	4,56	.67839	.51805	.723
TSC	4,56	1.83930	1.33980	.267
BSC	16,224	.42300	1.87788	.024
TBSC	16,224	.21721	.82477	.657

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

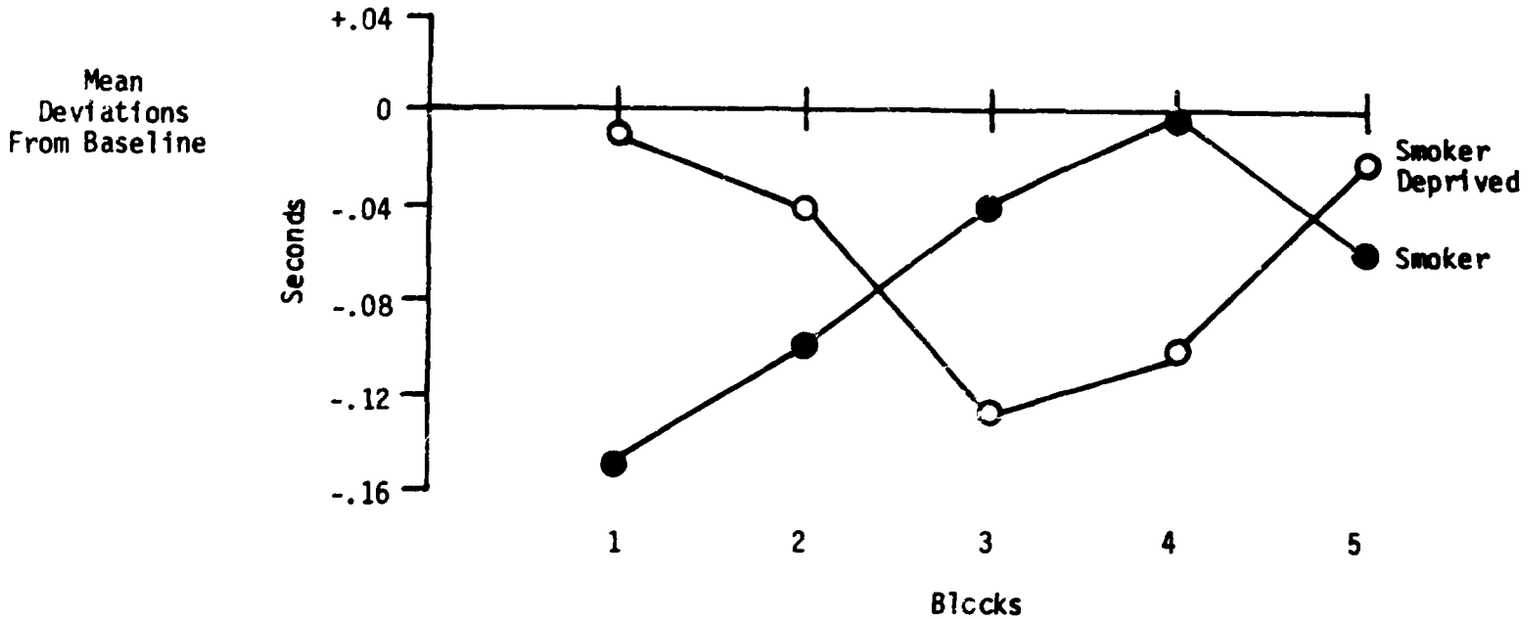

Figure 5

SMOKER VS. SMOKER DEPRIVED
ROOT MEAN SQUARE ERROR

Table 6

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	12.27161	3.10026	.092
B	4,92	.85784	1.72297	.152
TB	4,92	1.25311	2.51687	.047
S	2,46	1.77053	.63521	.534
TS	2,46	1.04844	.37615	.689
BS	8,184	.12990	.49639	.858
TBS	8,184	.15144	.57870	.795
C	2,46	.62180	.66417	.520
TC	2,46	.05947	.06352	.939
BC	8,184	.19769	.87433	.540
TBC	8,184	.23676	1.04590	.430
SC	4,92	2.05913	1.55980	.192
TSC	4,92	1.13421	.85917	.492
BSC	16,368	.19034	.94543	.517
TBSC	16,368	.26013	1.29212	.199

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

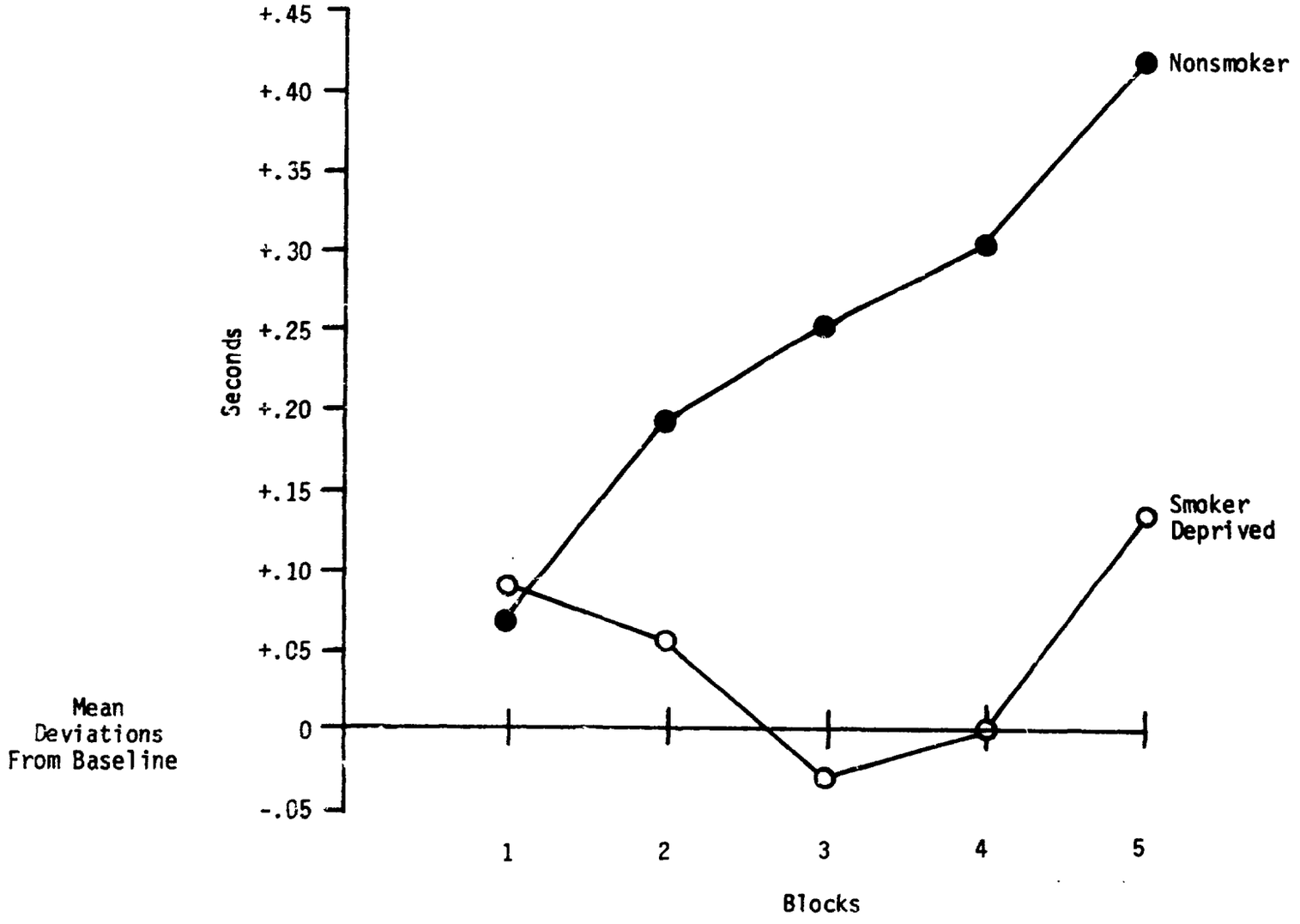

Figure 6

NONSMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

The analysis of variance summary tables for mean constant error and root mean square error in the nonsmoker vs. smoker deprived comparison can be seen in Appendix D. The only significant effect in either of these comparisons is a significant main effect for speed ($p = .024$) on the mean constant error measure, which is not of interest.

A final comparison was made between the nonsmoker and smoker subjects. For the analysis with mean absolute error, there were no significant effects. The analysis employing root mean square as the criterion produced only a significant block effect. Both of these tables can be seen in Appendix D.

In the nonsmoker vs. smoker comparison with mean constant error (Table 7), the only effect of real interest was a treatment x speed x concealment interaction ($p = .037$). In order to specify the nature of this interaction, several repeated measure one-way analysis of variance calculations were performed. Results of these analyses (Table 8) indicated that smokers differ in their performance for the three speeds under concealment one (visible shortest time). A Newman-Keuls post-hoc comparison of mean differences (Table 9) indicates that smokers under concealment one performed worse at speed one (fastest) than at speed two or three. A graph of this relationship for concealment one can be viewed in Figure 7. This particular effect did not occur for the nonsmoker subjects.

Table 7

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.01465	.00053	.982
B	4,92	2.32272	1.37207	.250
TB	4,92	1.32593	.78325	.539
S	2,46	6.75599	3.16660	.051
TS	2,46	.06387	.02994	.971
BS	8,184	.26473	1.05657	.396
TBS	8,184	.28270	1.12828	.346
C	2,46	1.20259	.67912	.512
TC	2,46	1.08445	.61240	.546
BC	8,184	.54978	2.07292	.041
TBC	8,184	.36174	1.36394	.215
SC	4,92	2.75338	1.90995	.115
TSC	4,92	3.85253	2.67240	.037
BSC	16,368	.26027	.83675	.643
TBSC	16,368	.13178	.42367	.976

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

Table 8

REPEATED MEASURE ONE-WAY ANALYSES
OF VARIANCE FOR SPEEDS
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p ≤
SMC1	2,28	3.0025	13.51	.01
NSC1	2,18	.721	3.06	
SMC2	2,28	.974	2.90	
NSC2	2,18	.255	.73	
SMC3	2,28	.054	.10	
NSC3	2,18	.332	1.77	

SM = Smoking Subjects
NS = Nonsmoking Subjects
C1 = Concealment 1
C2 = Concealment 2
C3 = Concealment 3

Table 9

NEWMAN-KEULS TEST OF DIFFERENCES
BETWEEN MEANS FOR SMOKERS AT
CONCEALMENT 1

Speeds		S3	S2	S1
	Means	-2.138	.116	10.448
S3	-2.138	---	2.254	12.586
S2	.116		---	10.332
S1	10.448			---

$q_{.99}(r,28)$	r = 2	r = 3
$\sqrt{\frac{MS\ res}{n}}$	3.88	4.46
$(q_{.99})(r,28)$ = 1.826	7.085	8.144

	3	2	1
3	-	-	*
2		-	*
1			-

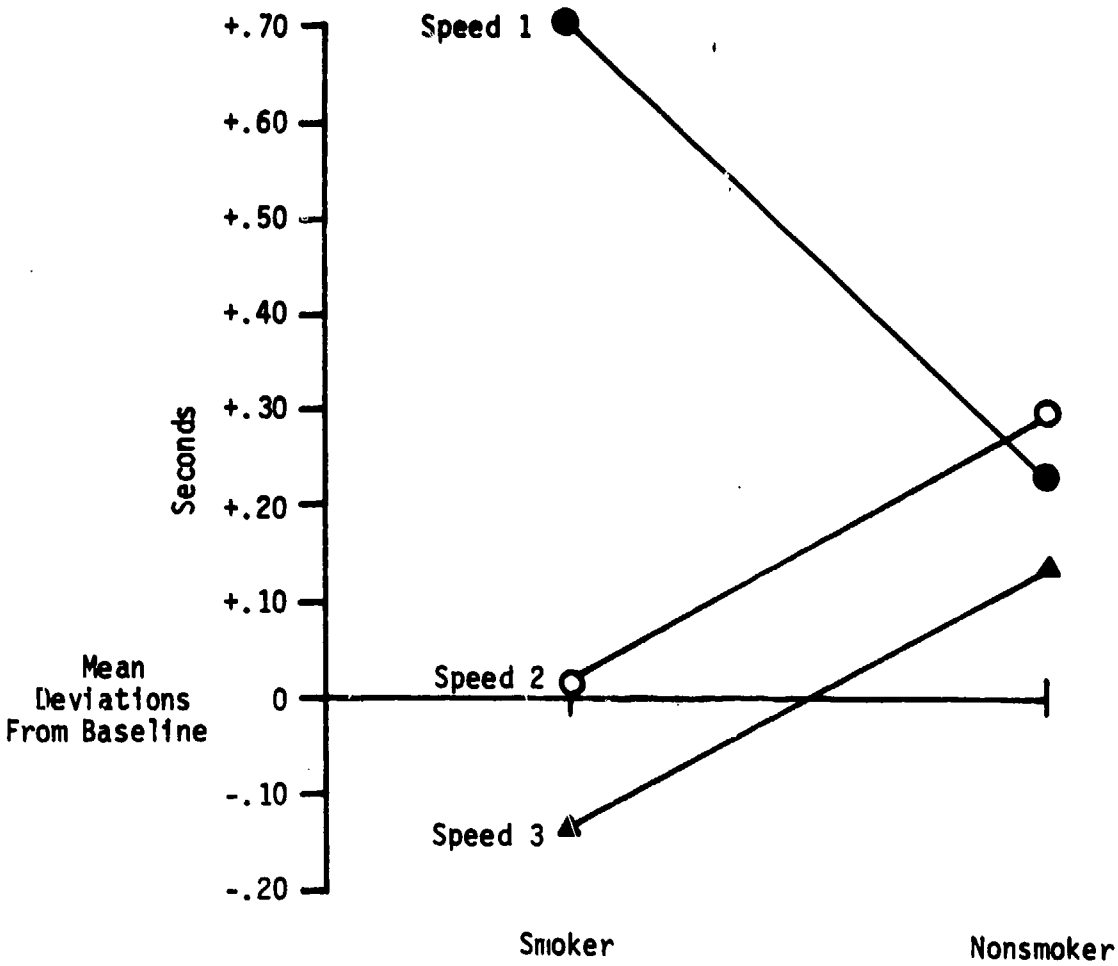

Figure 7

NONSMOKER VS. SMOKER
MEAN CONSTANT ERROR
CONCEALMENT 1

STUDY NUMBER II

INTRODUCTION

In many ballistic systems, operators must acquire a target, calculate its velocity, and fire ahead of the target to compensate for the lag between firing and impact of the target. This second study was conducted in order to determine the effect of cigarette smoking on the ability of subjects to perform this type of complex task. As in the first study, this investigation required the viewing of objects in the central visual field.

METHODS

Subjects

Twenty-five male volunteers from the student population of the University of South Dakota were selected to participate in this experiment. Subjects were screened in the same manner as the first experiment. A vision test, and a questionnaire concerning smoking habits and medical history were the criterion for selection. Fifteen of the subjects were classified as chronic smokers (SM), and the remaining ten were nonsmokers (NS).

Ages of the subjects ranged from 19 to 24 with a mean age of 21.0 years. Each of the volunteers in the smoker group participated in two experimental sessions and was paid fifteen dollars upon completion of the last session. Those in the nonsmoker group participated in only one experimental session and were paid seven dollars and fifty cents for their participation.

Prior to participation in the experiment, the subjects were informed of the requirements and purposes of the investigation and signed a consent form.

Apparatus and Task

The basic apparatus employed in this study was the same as the one utilized in the first study. The video display was situated on a table with a chair secured in front of it. The illumination level was also the same as in the first experiment.

Although the apparatus was the same, subjects were exposed to a different task. As can be seen from the schematic of the display screen in Figure 8, there were three arrowheads located near the bottom of the screen. On the actual display screen, the middle arrowhead was located horizontally at the center point. In addition, there was a distance of 2.82 cm. separating each of the outside arrowheads from

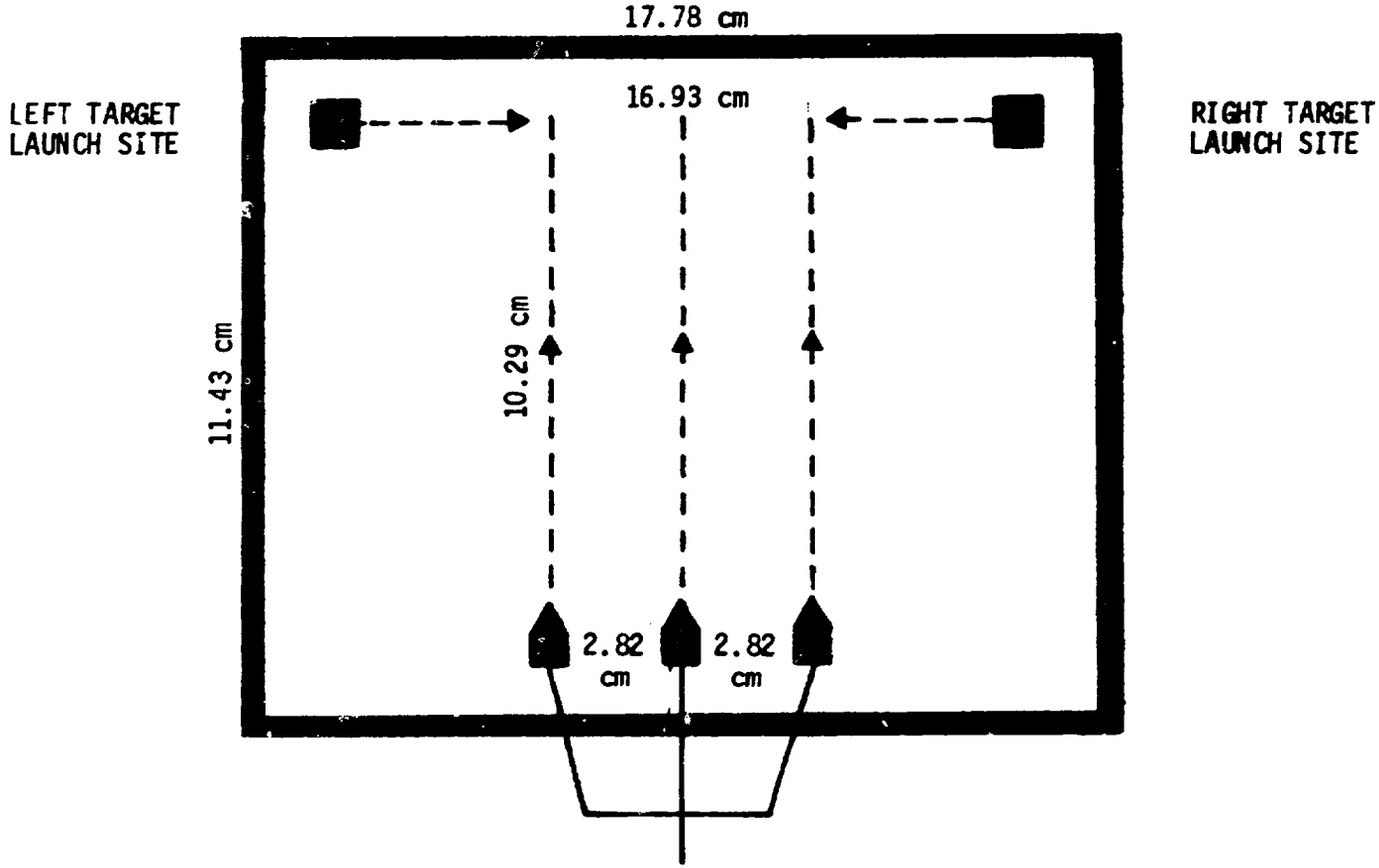

Figure 8

PROJECTILE
LAUNCH SITES

the middle one. Located near the top of the screen there were two squares (.47 cm. by .47 cm.) separated from each other by a distance of 16.93 cm.

When a buzzer sounded (two seconds before the initiation of a trial), one of the three arrowheads (projectiles) appeared, as well as one of the two squares (targets). At the initiation of the actual trial, the one square that had appeared at the top of the screen moved horizontally across the screen. The following three velocities were utilized for the target: 2.14 deg./sec., 1.43 deg./sec. and 1.07 deg./sec. As the target traveled across the screen, the subject's task was to press a hand held switch to launch the projectile and intercept the moving target. Upon pressing the switch the projectile moved vertically at a constant speed of 5.17 deg./sec. until it reached the point of impact with the target (1.5 sec. lag). The speed of the projectile remained constant for all trials. Once a trial had been completed, the target moved in a direction opposite to that in the preceding trial. The inter-trial interval for this task was 16 seconds. Another task parameter was the "exposure distance" of the moving target. This was the amount of time that a subject was allowed to view the moving target before pressing the switch to release the projectile. There were three different "exposure distances" presented to a subject, and these were determined by the launch site of the projectile. (Remember that only one projectile and one target could be seen on any given trial.)

As in the first experiment, the trials in this experiment were broken down into blocks in order to estimate the effects of cigarette smoking over time. Four trials of each of the 3 speeds and 3 exposure distances were presented within each block. Each of these parameters was randomly ordered within each block.

During the training period only, the subject received feedback with both the projectile and target remaining visible until an intercept occurred. If there was no intercept, the projectile disappeared and the moving target remained visible across the entire display screen. In the actual testing session, the target disappeared as soon as the subject pressed the switch, whereas the projectile remained visible until it reached the top of the screen. This procedure was utilized in the testing session to control for learning effects.

Measures

The scoring of responses was calculated and recorded by the computer. Scores with plus signs were assigned to those responses in which the projectile reached the point of collision after the target. A score with a minus sign was recorded when the projectile reached the point of impact before the target. The value zero was assigned when the projectile and target collided with one another.

As in the first experiment the scores were treated as deviations from baseline. Scores from the baseline block were subtracted from the post-treatment block scores. The following were the three measures utilized:

Mean Absolute Error. This measure was calculated by taking the mean of the responses disregarding their signed value. Mean absolute error indicates the overall magnitude of error.

Mean Constant Error. A simple arithmatic mean of the signed error responses. This measure reflects both the magnitude and direction of a subject's error.

Root Mean Square Error. This measure was obtained by calculating the standard deviation of the scores, indicating the variability of a subject's responses.

PROCEDURES

Fifteen subjects, who had been classified as chronic smokers, appeared under both smoking and smoking deprived conditions. Both sessions were scheduled for the same time of day with approximately 48 hours between the two sessions. Ten nonsmoking control subjects appeared for one session under the identical conditions as the smoker deprived subjects.

During an experimental session, subjects reported to a lounge two hours prior to testing. No food or beverages were allowed during the entire experimental session and all cigarettes were taken away from the volunteers serving under the smoking and smoking deprived conditions.

The first 35 minutes of the experimental session served as a training period for the subjects. After the instructions had been fully explained by the experimenter, the subject was seated in front of the display and was allowed to practice a full 30 minutes on the task. The same speeds and exposure distances were presented during the training. Following the training session, subjects were sent back to the lounge for the remainder of the two hour waiting period.

At the conclusion of the waiting period, the subjects were taken to the experimental room to begin the 60 minute testing session. The first 10 minutes served as a pre-treatment baseline period to account for subject variability not due to treatment. After the baseline period, a 10 minute break in testing was given to allow subjects in the smoker treatment group to smoke one cigarette. The cigarettes were the same as those used in the first study. The cigarette treatment was counterbalanced, as in the previous study, with half of the subjects receiving the smoker treatment the first day and smoker deprived treatment the second day, while the other half received the smoker deprived treatment the first day and the smoker

treatment the second day. The 10 minute treatment period served only as a rest period for subjects in the nonsmoker and smoker deprived groups since neither of these groups were given a cigarette.

Following the break, post-treatment trials were presented to measure performance changes due to the administration of the smoking treatment.

For subjects in the smoker and smoker deprived treatment groups the experimental session on the second day was the same as the first day except that the training period lasted 10 minutes instead of 30 minutes.

Data Analysis

This investigation was designed to determine the effects of cigarette smoking on the ability to view a target, calculate its speed, and fire a projectile ahead of the target to compensate for the time lag between firing of the projectile and its impact with the target. The data analysis procedures for this experiment were identical to the ones employed in the first study.

A 2 x 4 x 3 x 3 (treatment groups, blocks, speeds, and exposure distances) factorial design with repeated measures across all levels of each factor was employed in the analysis of variance to compare the smoker with the smoker deprived groups. As a means of comparing the nonsmoking subjects with smoker deprived subjects as well as the nonsmokers with the smokers, a 2 x 4 x 3 x 3 (treatment groups, blocks, speeds, and exposure distances) factorial design with repeated measures over the block, speed, and exposure distance factors was utilized in the analysis of variance.

RESULTS

Table 10 is the analysis of variance summary table for the smoker vs. smoker deprived comparison using the mean absolute error measure. In this analysis there was a near significant smoking treatment x speed x exposure interaction ($p = .059$). There was also a significant block effect ($p = .003$). Tests for simple effects were performed to specify the relationship of the three-way interaction. As can be seen by the results of this analysis (Table 11), there were significant differences between the treatment groups for the speed one (fastest), exposure three (longest) combination, the speed three (slowest), exposure two combination, and the speed three, exposure three combination. In viewing the graph in Figure 9, it can be seen that the smokers actually performed better than smoker deprived subjects at the three different speed and exposure distance combinations. It was apparent in looking at the significant block effect that subjects in both treatment groups tended to perform better in the first two blocks of time than in the last two. This difference in performance for blocks could be explained as a possible fatigue effect.

Table 10

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	1.03540	1.76191	.206
B	3,42	.31286	5.53158	.003
TB	3,42	.08653	2.10529	.114
S	2,28	.00468	.02758	.973
TS	2,28	.10307	.58039	.566
BS	6,84	.01408	.62425	.710
TBS	6,84	.03700	1.81782	.105
C	2,28	.03144	.24691	.783
TC	2,28	.03191	.25646	.776
BC	6,84	.01636	.75406	.608
TBC	6,84	.01412	.60207	.728
SC	4,56	.12981	.99021	.420
TSC	4,56	.18502	2.41860	.059
BSC	12,168	.02371	.81275	.637
TBSC	12,168	.02711	1.28175	.233

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table 11

TEST OF SIMPLE EFFECTS
SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	MS	F	p <
T at S1C1	.117	1.529	
T at S1C2	.025	.327	
T at S1C3	.586	7.660	.01
T at S2C1	.206	2.693	
T at S2C2	.0001	.001	
T at S2C3	.015	.196	
T at S3C1	.002	.026	
T at S3C2	.343	4.480	.05
T at S3C3	.345	4.510	.05
ERROR	.077		

df = 1,56
$F_{.05}(1,56) = 4.02$

T = Smoking Treatment
S = Speed of Moving Target
C = Exposure Distance

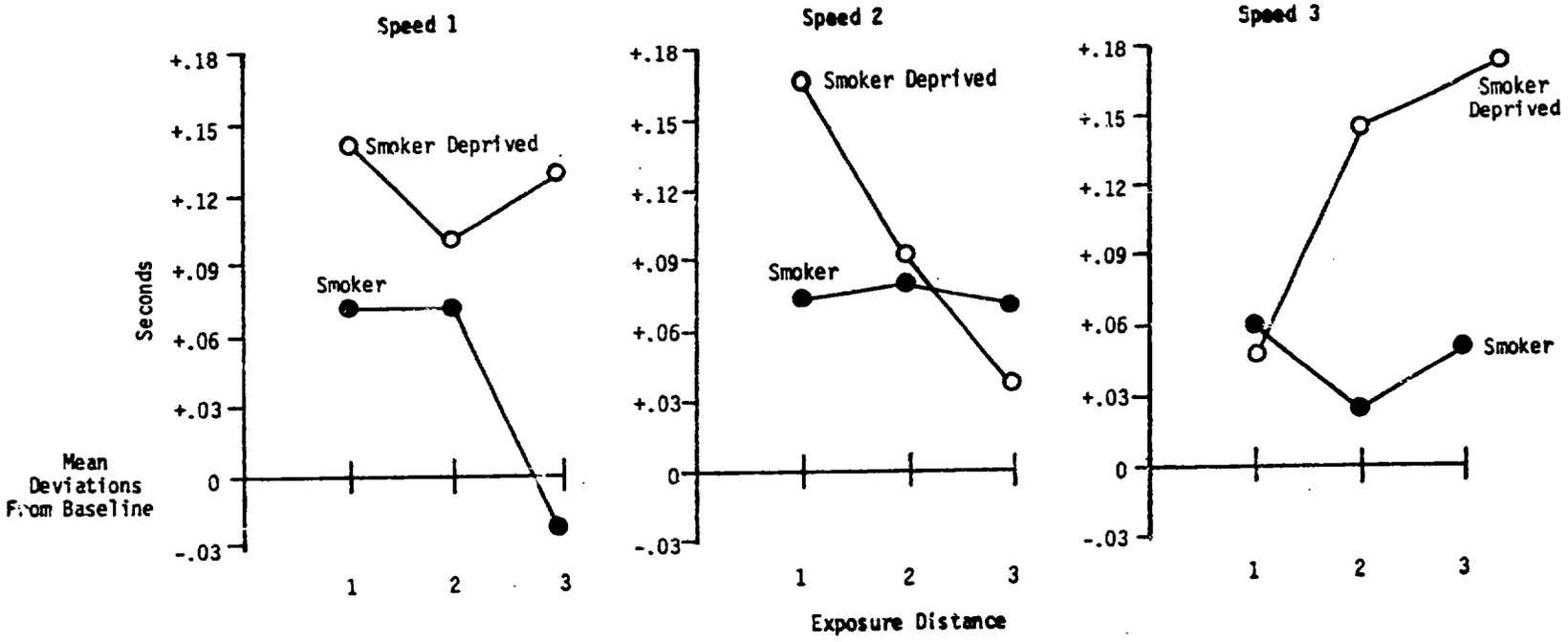

Figure 9

SMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

In the other smoker vs. smoker deprived comparisons there were no significant effects for either mean constant error or root mean square error. Summary tables for these two analyses can be seen in Appendix E.

Table 12 contains a summary of the analysis of variance for the nonsmoker vs. smoker deprived comparison with mean absolute error. Significant effects were found for the block x speed x exposure interaction ($p = .011$), the speed x exposure interaction ($p = .008$), and the main effect for blocks ($p = .027$). As in the first study, deviation from baseline scores were used in the analysis of variance calculations. Therefore, the effects of speeds and exposures which are not associated with the smoking treatment are not particularly meaningful. In examining the block effect, however, it was determined through calculations of the mean performances of the groups in each block that performance was better in the early blocks than in later ones. This effect was the same for both SM and NS groups, however. Results for mean constant error (Table 13) revealed a statistically significant effect for the speed x exposure interaction ($p = .006$) and block x speed interaction ($p = .045$). There were no significant effects in the nonsmoker vs. smoker deprived comparison for root mean square error (Appendix E).

In comparing differences between nonsmokers and smokers for mean absolute error there were no significant effects of interest. The summary table for this analysis can be seen in Appendix E. Table 14 is the summary of the nonsmoker vs. smoker comparison for mean constant error. Results indicate a statistically significant speed x exposure interaction ($p = .048$). The final analysis for root mean square error had absolutely no statistical significance and can be found in Appendix E.

Table 12

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.69178	1.05578	.315
B	3,69	.24107	3.26222	.027
TB	3,69	.04285	.57979	.630
S	2,46	.13684	1.05035	.358
TS	2,46	.02099	.16108	.852
BS	6,138	.02636	.86322	.524
TBS	6,138	.03202	1.04851	.397
C	2,46	.07365	.55298	.579
TC	2,46	.05374	.40346	.670
BC	6,138	.03873	1.32780	.249
TBC	6,138	.02142	.73436	.623
SC	4,92	.37006	3.70794	.008
TSC	4,92	.14419	1.44481	.226
BSC	12,276	.06976	2.22183	.011
TBSC	12,276	.03679	1.17193	.303

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table 13

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	3.47774	2.05408	.165
B	3,69	.02472	.20348	.894
TB	3,69	.13334	1.09750	.356
S	2,46	.41127	1.48187	.238
TS	2,46	.59285	2.13616	.130
BS	6,138	.09098	2.21130	.045
TBS	6,138	.05727	1.39195	.222
C	2,46	.23521	.84261	.437
TC	2,46	.13303	.37971	.686
BC	6,138	.05213	1.44900	.200
TBC	6,138	.04845	1.34547	.241
SC	4,92	.87732	3.87736	.006
TSC	4,92	.08298	.36675	.832
BSC	12,276	.04427	1.22910	.262
TBSC	12,276	.03378	.93778	.509

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table 14

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	1.54431	.94550	.341
B	3,69	.11866	1.00284	.397
TB	3,69	.03865	.32666	.806
S	2,46	.49085	2.20552	.122
TS	2,46	.50594	2.27333	.114
BS	6,138	.08792	2.01607	.068
TBS	6,138	.09211	2.11208	.056
C	2,46	.50342	1.86036	.167
TC	2,46	.13524	.49978	.610
BC	6,138	.02677	.74168	.617
TBC	6,138	.05187	1.43703	.205
SC	4,92	.49057	2.49374	.048
TSC	4,92	.21093	1.07224	.375
BSC	12,276	.05371	1.61488	.087
TBSC	12,276	.02257	.67870	.772

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

DISCUSSION

Previous research in this laboratory (Scoughton and Heimstra, 1973, 1975) indicated that cigarette smoking had a detrimental effect on the ability of subjects to estimate the velocity of moving objects viewed in the peripheral field. The task involved viewing a moving object exposed for a brief period, and then estimating its time of impact with a stationary target, after a variable concealment distance. The nicotine effects were observed over a wide range of object speeds and concealment distances. The purpose of the first study reported here was to determine if these effects persisted when objects were viewed in the central field of vision.

The results of this study indicated that the nicotine effects were still present, but were detected only for certain combinations of object speed and concealment distance. In particular, there were statistically significant differences (in mean constant error) between smoking and smoking deprived subjects only for the fastest speed, shortest viewing time combination, and the slowest speed, longest viewing time combination. In both cases, the smokers performed worse in the post treatment trials than in the baseline period prior to treatment, while the deprived smokers stayed at about the same level of performance or improved slightly. Similar results were obtained for the mean absolute error measure.

It is obvious that the detrimental nicotine effects are not robust over a wide range of speed and concealment conditions when objects are viewed centrally, which is not consistent with the nature of these effects when objects are viewed peripherally. The differences found in the present study did occur at the extreme levels of speed and concealment used, however, and one might speculate that differences would also be found with more extreme speed and concealment values.

The second study reported here was conducted to determine the effects of nicotine on the ability of subjects to estimate the velocity of a moving target and fire ahead of the target to compensate for the time lag in a projectile trajectory. As in the first study, statistically significant effects were detected only for specific speed and exposure distance combinations. In particular, the smoker and smoker deprived groups differed in the fastest speed, longest viewing time combination, the slowest speed, medium viewing time combination, and the slowest speed, longest viewing time combination. Again, differences were found only at the extreme levels of speed. No differences were found under the shortest viewing time, which was the most difficult condition since subjects had only a brief time to estimate the target velocity and make a response. This may have precluded the detection of any nicotine effects, since error magnitudes and variability were large for all subjects under this condition.

The most interesting aspect of the results of the second study is that in each instance where differences were detected, the smoking subjects actually performed better than the deprived smokers. This is contrary to the results obtained previously, in both the centrally and peripherally presented tasks. This inconsistency is probably due to the nature of the tasks. The tasks used previously were pure velocity estimation tasks, while the task used in this last study not only required subjects to make velocity estimates, but also to integrate these estimates with the projectile lag. Here the spatial/temporal integration requirements indicate that higher levels of information processing are involved in performing this task.

In conclusion, the Scoughton and Heimstra studies determined that nicotine has a detrimental effect when estimating the velocity of objects viewed in the peripheral field of vision. The first study reported here indicated that this detrimental effect is not present over as wide a range of test conditions when the objects are viewed centrally. In the last investigation, where the task also involved higher levels of information processing than the pure velocity estimation tasks, the smoking effect disappeared, or, in fact, was reversed.

The practical significance of these results is, of course, dependent upon the nature of the tasks performed in operational situations. If velocity estimates are required for peripherally viewed objects, the nicotine effects are clearly negative and persistent over a wide range of task characteristics. More realistically, however, once an object is detected peripherally, the scene can be fixated centrally through appropriate head and eye movements, in which case the nicotine effects will not necessarily occur. More importantly, if the task being performed involves higher levels of information processing, there is no evidence that nicotine will have a detrimental effect. In this case, the inter-individual variability in performing the higher level information processing is greater than the effects of nicotine on the velocity estimation component of the task.

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APPENDIX A

Subject Questionnaire

Name:_____ Sex:_____

Vermillion Address: _____

Phone:_____ Age:_____

1. Are you currently taking medication? Yes____ No____

   What are you taking? _____ For what

   ailment? _____

2. Have you had or do you now have high blood pressure? Yes__ No__

3. Do you now smoke? Yes____ No____ . If no, have you ever been a

   regular smoker? Yes____ No____. How long since you quit? _____

   (if you do not smoke now, go to item #13)

4. What do you smoke? (Check all forms of tobacco used.)

   (a) cigarettes ____ (b) cigars ____ (c) pipe ____

   (d) other (please specify) _____

5. How much do you smoke a day? (If more than one form of tobacco is used, specify the amount of each per day.)

   (a) cigarettes _____ (b) cigars _____

   (b) pipe (bowlsfull or ounces) _____ (d) other _____

6. How long (in years and months) have you smoked this amount?

   _____

7. Do you inhale when you smoke the following?

   (a) cigarettes: Yes ____ No ____
   (b) cigars: Yes ____ No ____
   (c) pipe: Yes ____ No ____

   (If no is checked for all three categories, go to item #10.)

8. How often do you inhale each of the following?

   (a) cigarettes: Always ____ Usually ____ Occasionally ____
   (b) cigars: Always ____ Usually ____ Occasionally ____
   (c) pipe: Always ____ Usually ____ Occasionally ____

9. When some people inhale, they nearly fill their lungs with smoke; others barely let the smoke past their throat. Rate yourself as to your smoke inhalation depth on the type of smoking you do most, i.e., cigarettes, cigars, pipe.

The smoke completely fills my lungs _____
fills my lungs to about 3/4 full _____
fills my lungs to about 1/2 full _____
fills my lungs to about 1/4 full _____
just barely gets into my lungs _____

10. If you smoke cigarettes, what brand (or brands) do you usually smoke? _____

11. Are these filter cigarettes? Yes____ No____

Are they regular____ king-size____, or 100's____

12. What type of smoker do you consider yourself to be?

(a) regular ____ (smoke consistently day-after-day)

(b) irregular ____ (smoke only on occasion)

(1) light smoker ____

(2) moderate smoker ____

(3) heavy smoker ____

Thus you may be a regular light smoker, or an irregular heavy smoker, etc.

APPENDIX B

Consent to Participate Form

CONSENT TO PARTICIPATE

I, the undersigned, having been fully informed by Dr. Norman W. Heimstra of the requirements of the investigation "The Effects of Smoking on Time Estimation Performance" being conducted by the Human Factors Laboratory of the Department of Psychology, University of South Dakota, do hereby consent to participate in this investigation.

I understand that I will be required to participate on two occasions as a subject, that I will not be allowed to smoke on one test session, that I will be allowed to smoke during one of the test sessions, and that I will be paid for my participation upon successful completion of all test sessions.

Upon completion of the investigation, the Human Factors Laboratory will furnish me with a summary of the purposes of the investigation. I certify that I am 18 years of age or older, have the legal capacity to give my consent, and have exercised free power of choice in giving this consent.

I understand that I may at any time during the course of this study revoke my consent and withdraw from the study without prejudice; however, I may be requested to undergo certain further examinations, if in the opinion of the attending physician such examinations are necessary for my health or well being.

_____

Signature Date

_____

Witness Date

APPENDIX C

Instructions

INSTRUCTIONS TO TRAINING SESSION STUDY NUMBER I

The task which you will be performing involves the estimation of time. You will be presented with two concentric rectangles created on the video display in front of you. On the display a small rectangle appears to be located behind a larger rectangle. There are both approaching and receding trials in this task. In an approaching trial, a small target rectangle will "appear" out of the small stationary rectangle and move toward the large stationary rectangle. The target rectangle will then disappear at various points along its path and will travel at varied speeds. After the completion of an approaching trial, a receding trial will occur in which a large target rectangle will "appear" out of the large stationary rectangle and will move toward the small stationary rectangle. As in the approaching trials, the target in the receding trials will travel at varied speeds and will disappear at varied concealment points. Thus in an approaching trial, the moving target will appear to be moving toward you and in a receding trial will appear to be moving away from you.

Two seconds prior to the initiation of a trial, you will receive a warning signal in the form of a buzzer. At the onset of an actual trial, a target rectangle will appear out of one rectangle and will proceed to move toward the other rectangle. At some point along the way the target rectangle will disappear. What I would like you to do then is to press (handing him the switch) this switch (once and only once) when you feel that the moving target rectangle, which has disappeared, would perfectly superimpose the stationary rectangle (that it is moving towards).

At the end of each trial you will be given feedback as to how well you are performing on this task. This feedback will tell you whether you were early or late. A minus sign indicates that you pressed the switch before the moving target superimposed the stationary rectangle. A plus sign indicates that you pressed the switch after the moving target superimposed itself over the stationary rectangle.

Along with this information, you will find out how close you were in magnitude to the nearest hundredth of a second. For example, if the feedback you received was -1.50 it would mean that you were one and one-half seconds too early; whereas, +1.50 would indicate that you pressed the switch one and one-half seconds too late.

Once again, you are to press the switch when you think that the moving target, which has disappeared, would superimpose the stationary rectangle. Make sure that you press the switch once and only once for each trial. There are a total of 56 trials in all in this training session. Are there any questions?

INSTRUCTIONS TO EXPERIMENTAL SESSION STUDY NUMBER I

The task which you are being asked to perform requires an estimation of time. You will recall that during the training session that two seconds prior to the initiation of a trial a warning signal sounded as a buzzer. At the initiation of a trial a target rectangle appeared out of the smaller rectangle and moved toward the large stationary rectangle. The target travelled at different speeds and while on its path, was concealed from your view at some point. On the receding trial the target "appeared" out of the large rectangle and moved away from you toward the smaller rectangle.

Almost the exact same events will occur in the experimental session as had occurred in the training session. The only thing that is different in the experimental session is that you will not receive feedback as to how well you are performing. The task required of you in this experimental session is to press the switch when you believe that the moving target (which has been concealed at some point along the way) will perfectly superimpose the stationary rectangle that it is moving towards.

There are 36 trials in this first part of the test session, after which you will receive a 10 minute break. Following the break there will be 180 trial presentations.

Are there any questions? Remember that everything is the same as in the training session except that you won't receive any feedback.

INSTRUCTIONS TO TRAINING SESSION STUDY NUMBER II

In this experiment, your task will be to press this switch (handing him the switch) in order to launch a projectile at the bottom of the screen and intercept the moving target at the top of the screen. When the projectile (that you have launched) reaches the top of the screen and intercepts the target, both the target and projectile will disappear. The only way that both of them will disappear is when the projectile intercepts the target. Your objective in this study is to cause the projectile to intercept the target as often as possible.

Keep in mind that it takes one and one-half seconds for the projectile to reach the point of impact with the target. This time will be constant for all trials. Also, the target will travel at different speeds, with the speed being constant the entire distance across the screen. There are three different launch sites in which the projectile will be located.

Two seconds prior to the initiation of each trial a buzzer will sound as a warning signal. At that same moment, one of the targets at the top of the screen and one projectile at the bottom of the screen will appear. At the initiation of a trial, the target will start moving. Remember that it is your task to launch the projectile (by means of the switch in your hand) to intercept the target. One other point to keep in mind is that the target will move horizontally in the opposite direction that it moved on the preceding trial. The target will move from left to right on the first trial and right to left on the second trial, and so on.

Once the training begins you will have a total of 108 trials in which to practice. Are there any questions?

INSTRUCTIONS TO EXPERIMENTAL SESSION STUDY NUMBER II

In this experimental session you will be performing almost the identical task that you had performed in the training session. Your objective is to launch the projectile so that it will intercept the moving target. The target will travel at the same speeds and the projectile will be located at the same launch sites. There will again be a one and one-half second time lag between the launching of a projectile and its eventual reaching of the point of interception with the target.

The only difference that there will be in the experimental session is that you will not receive any feedback as to how well you are performing. Once you press the switch, you will see the projectile on its path as you had in the training session; however, you will not be able to see the target moving. The target will disappear once you press the switch. There are a total of 36 trials in the first part of the experimental session. After you have completed the first part of the task you will then receive a 10 minute break. Following the break, you will be presented with a total of 144 trials.

Are there any questions?

APPENDIX D

Analysis of Variance Summary Tables for Study No. I

Table D-1

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	13.94434	.66988	.421
B	4,92	1.40758	.78763	.536
TB	4,92	2.32166	1.29913	.276
S	2,46	9.61180	4.02674	.024
TS	2,46	.59679	.25002	.780
BS	8,184	.14326	.56668	.804
TBS	8,184	.20288	.80249	.601
C	2,46	4.24477	2.22522	.120
TC	2,46	3.14581	1.64911	.203
BC	8,184	.61422	1.70053	.101
TBC	8,184	.29259	.81006	.595
SC	4,92	1.05528	.62632	.645
TSC	4,92	.53286	.31626	.866
BSC	16,368	.28794	.89110	.580
TBSC	16,368	.23584	.72987	.763

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

Table D-2

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	2.93779	1.18965	.287
B	4,92	.65517	1.73081	.150
TB	4,92	.45495	1.20187	.315
S	2,46	1.47496	.94137	.397
TS	2,46	.40495	.25845	.773
BS	8,184	.06039	.28156	.971
TBS	8,184	.16005	.74616	.651
C	2,46	.14737	.13643	.873
TC	2,46	1.39303	1.28965	.285
BC	8,184	.05471	.25365	.979
TBC	8,184	.17140	.79461	.608
SC	4,92	1.22352	.87147	.484
TSC	4,92	.47286	.33681	.853
BSC	16,368	.20096	.94092	.522
TBSC	16,368	.22952	1.07467	.378

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

Table D-3

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.79662	.12735	.724
B	4,92	1.29904	2.16313	.079
TB	4,92	.87814	1.46226	.220
S	2,46	6.26281	1.88421	.163
TS	2,46	.14263	.04291	.958
BS	8,184	.21854	.75040	.647
TBS	8,184	.17078	.58641	.788
C	2,46	.01089	.00901	.991
TC	2,46	.23490	.19432	.824
BC	8,184	.29970	1.48214	.166
TBC	8,184	.11384	.56299	.807
SC	4,92	1.98903	2.04688	.094
TSC	4,92	1.10102	1.13304	.346
BSC	16,368	.09145	.46787	.961
TBSC	16,368	.28894	1.47832	.105

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

Table D-4

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	P
T	1,23	3.56383	1.75666	.198
B	4,92	.79610	2.54323	.045
TB	4,92	.37303	1.19170	.320
S	2,46	3.34927	2.09077	.135
TS	2,46	.17386	.10853	.897
BS	8,184	.06752	.23299	.984
TBS	8,184	.13001	.44861	.890
C	2,46	.05235	.03882	.962
TC	2,46	2.16921	1.60850	.211
BC	8,184	.15054	.66141	.725
TBC	8,184	.19188	.84307	.566
SC	4,92	.21609	.16017	.958
TSC	4,92	1.34779	.99897	.412
BSC	16,368	.19407	.77316	.716
TBSC	16,368	.12667	.50466	.945

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Concealment of Target

APPENDIX E

Analysis of Variance Summary Tables for Study No. II

Table E-1

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
MEAN CONSTANT ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	.48387	.46584	.506
B	3,42	.05379	.64788	.589
TB	3,42	.05487	.74217	.533
S	2,28	.00664	.02388	.976
TS	2,28	.21751	1.22658	.309
BS	6,84	.02664	.81123	.564
TBS	6,84	.02837	.86364	.525
C	2,28	.19722	1.34205	.278
TC	2,28	.10567	.44260	.647
BC	6,84	.08276	2.13046	.058
TBC	6,84	.02152	.62293	.711
SC	4,56	.37531	2.08481	.095
TSC	4,56	.20968	1.23472	.307
BSC	12,168	.03543	1.05875	.398
TBSC	12,168	.05026	1.73483	.063

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table E-2

ANALYSIS OF VARIANCE SUMMARY TABLE
SMOKER VS. SMOKER DEPRIVED
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,14	.08820	.35982	.558
B	3,42	.12577	1.94177	.138
TB	3,42	.01193	.36005	.782
S	2,28	.28089	1.88183	.171
TS	2,28	.09951	.51010	.606
BS	6,84	.04779	1.33640	.250
TBS	6,84	.01785	.41725	.866
C	2,28	.02212	.15871	.854
TC	2,28	.19267	2.02669	.151
BC	6,84	.00552	.20260	.975
TBC	6,84	.02084	.73638	.622
SC	4,56	.13099	.71004	.589
TSC	4,56	.06814	.61818	.651
BSC	12,168	.03658	1.13486	.335
TBSC	12,168	.02114	.65484	.792

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table E-3

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER DEPRIVED
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.03360	.16744	.686
B	3,69	.05846	1.04806	.377
TB	3,69	.02542	.45566	.714
S	2,46	.08930	.53779	.588
TS	2,46	.34833	2.09778	.134
BS	6,138	.07508	1.26385	.278
TBS	6,138	.03007	.50621	.803
C	2,46	.15700	.99377	.378
TC	2,46	.04610	.29178	.748
BC	6,138	.03967	.96786	.449
TBC	6,138	.04141	1.01031	.421
SC	4,92	.19363	1.37450	.249
TSC	4,92	.04851	.34435	.847
BSC	12,276	.04895	1.04865	.404
TBSC	12,276	.02049	.43905	.947

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table E-4

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
MEAN ABSOLUTE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.00613	.00658	.936
B	3,69	.11018	1.51782	.218
TB	3,69	.01293	.17812	.911
S	2,46	.00949	.04937	.952
TS	2,46	.18260	.95020	.394
BS	6,138	.04656	1.57472	.159
TBS	6,138	.03781	1.27876	.271
C	2,46	.02239	.16084	.852
TC	2,46	.15175	1.09011	.345
BC	6,138	.03855	1.32094	.252
TBC	6,138	.03772	1.29255	.265
SC	4,92	.15388	1.25924	.292
TSC	4,92	.22287	1.82381	.131
BSC	12,276	.05073	2.33641	.007
TBSC	12,276	.05715	2.63194	.002

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

Table E-5

ANALYSIS OF VARIANCE SUMMARY TABLE
NONSMOKER VS. SMOKER
ROOT MEAN SQUARE ERROR

Source	df (Hypoth,Error)	MS	F	p
T	1,23	.20154	1.03540	.319
B	3,69	.03688	.62511	.601
TB	3,69	.04669	.79129	.503
S	2,46	.03742	.32360	.725
TS	2,46	.13992	1.21013	.307
BS	6,138	.02520	.68886	.659
TBS	6,138	.05488	1.50014	.183
C	2,46	.10967	.82639	.444
TC	2,46	.16978	1.27937	.288
BC	6,138	.04852	1.72142	.120
TBC	6,138	.03069	1.08870	.372
SC	4,92	.13672	1.09074	.366
TSC	4,92	.01810	.14439	.965
BSC	12,276	.01900	.65656	.792
TBSC	12,276	.02956	1.02149	.429

T = Smoking Treatment
B = Blocks
S = Speed of Moving Target
C = Exposure Distance

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